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Question [1]: [25 mark]

(a) Convert the following numbers showing all steps.

$(100011)_2 = (\ 35\ )_{10}$ ✓3

$(1010\ 0110)_{excess-3} = (\ 1001\ 0100\ )_{6-3-1-1}$ ✓3

$(\ 0111\ \ 0011\ )_{BCD} \rightarrow (\ 73\ )_{10}$

$(\ 1100\ )_2 = (0001\ \ 0010\ )_{BCD}$ ✓3

$(\ 12\ )_{10}$

$(A2B3)_{16} = (\ 121263\ )_8$ ✓3

$(\ 1010\ 0010\ 1011\ 0011\ )_2$

$(11101000)_{2's\ complement} = (\ 11100111\ )_{1's\ complement}$ ✓3

(c) Perform the following operation in 2's complement using 5-bit word. Then indicate if **there is an overflow.**

$(-16)_{10} + (-15)_{10} =$

$-16 \rightarrow 10000$

$-15 \rightarrow 10001 +$

$10000\ 1$ ✓

$= -1$ ✓

$-16 \rightarrow 10000$

$15 \rightarrow 01111 \rightarrow 10000 \rightarrow 10001$

(4)

(d) Divide in binary 10110111 by 110 (long division).

11110.1 ← the answer

$110\ \overline{)\ 10110111}$

110

0010

110

0011

110

0111

110

00110

110

000

✓ (5)

Question [2]: [25 mark]

1- Use Boolean Algebra to simplify the following expression

$$F = x + (y\bar{z} + \bar{y}z)(\overline{y \oplus z}) + \bar{x}y(wz + \overline{wz})$$

$\overline{y \oplus z} = \bar{y}z + \bar{z}y$

$= (y + \bar{z})(\bar{z} + \bar{y})$

$= x + (y\bar{z} + \bar{y}z)(y \oplus z) + \bar{x}y(w + \overline{wz})$

$= x + y + (y\bar{z} + \bar{y}z)(y \oplus z)$

$= x + y + (y \oplus z)(\overline{y \oplus z})$

$= x + y$

$x + \bar{x} = 1$

$x\bar{x} = 0$

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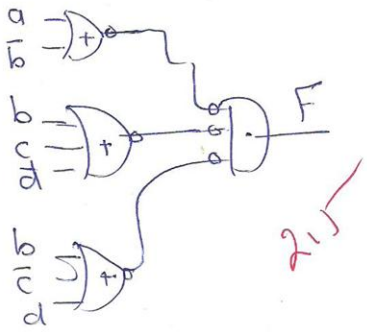
→ POS

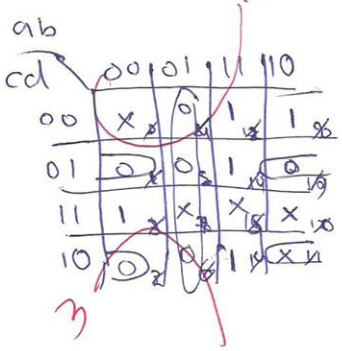
2- Implement the following function with a minimum number of NOR gates:

$$F(a,b,c,d) = \Sigma m\,(3,8,12,13,14) + \Sigma d\,(0,7,10,11,15)$$

$F = (a + \bar{b})(b + c + \bar{d})(b + \bar{c} + d)$

2↓ 2↓





Question [3]: [25 mark] 25

Four chairs (A, *B, C,* and *D)* are placed in a circle: *A* next to *B, B* next to *C, C* next to *D,* and *D* next to *A*. Each chair may be occupied (1) or empty (0).

Express the outputs in a Truth Table and give the required logic functions for each condition described below;

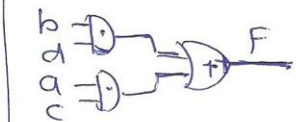
a) Find the minterm expansion in decimal form for F(A, B, C, D) being 1 iff there are no adjacent empty chairs

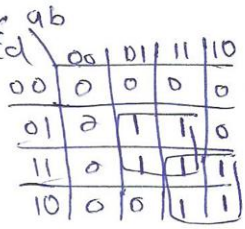
b) Find the Maxterm expansion in decimal form for G(A, B, C, D) being 1 iff at least three chairs are full

m	A B C D	F	G
0	0 0 0 0	0	0
1	0 0 0 1	0	0
2	0 0 1 0	0	0
3	0 0 1 1	0	0
4	0 1 0 0	0	0
5	0 1 0 1	1	0
6	0 1 1 0	0	0
7	0 1 1 1	1	1
8	1 0 0 0	0	0
9	1 0 0 1	0	0
10	1 0 1 0	1	0
11	1 0 1 1	1	1
12	1 1 0 0	0	0
13	1 1 0 1	1	1
14	1 1 1 0	1	1
15	1 1 1 1	1	1

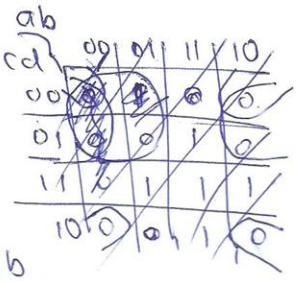
(a) $\Sigma m(5,7,10,11,13,14,15)$

$F = bd + ac$

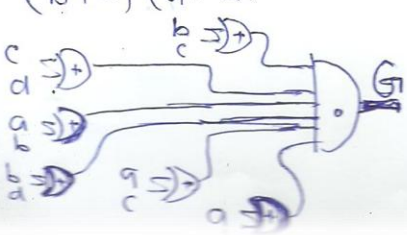


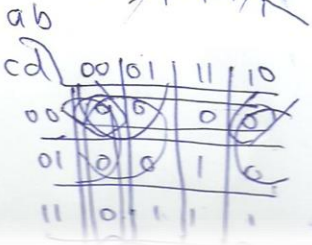


(b) $\Pi m(0,1,2,3,4,5,6,8,9,10,12)$



$G = (c+d)(a+b)(b+d)(a+c)(b+c)(a+d)$



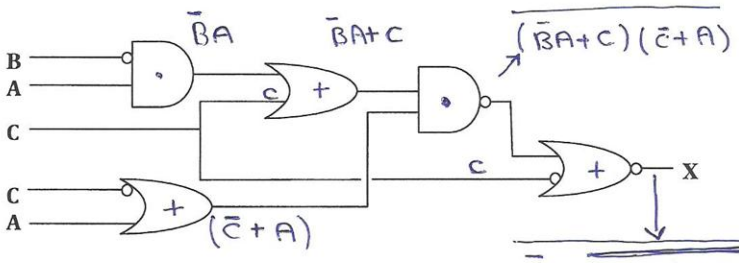


Question [4]: [25 mark]

For the logic diagram shown below;

a) Write the output expression in minimum Sum of Products Form,

b) Redraw the circuit using a two level circuit with a minimum number of NAND gates only, (you can use NAND gates as inverters in your circuit if required)



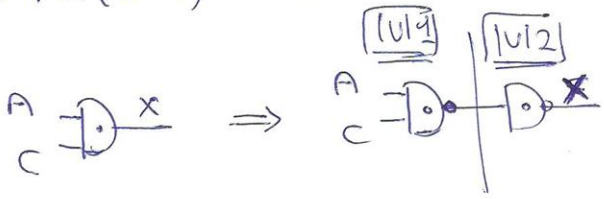
$\bar{C} + (\bar{B}A+C)(\bar{C}+A)$

$X = \overline{\bar{C} + (\bar{B}A+C)(\bar{C}+A)} = (\bar{\bar{C}})\overline{(\bar{B}A+C)(\bar{C}+A)}$

$= C(\bar{B}A+C)(\bar{C}+A) = (A\bar{B}C+C)(\bar{C}+A)$

$= A\bar{B}C\bar{C} + AA\bar{B}\bar{C} + C\bar{C} + CA = A\bar{B}C + AC$

$= AC(\bar{B}+1) = AC$



$\overline{AC} = \bar{A}+\bar{C} \rightarrow \overline{\bar{A}+\bar{C}} = AC = AC$